# INDOOR AIR QUALITY ASSESSMENT

**Charlotte M. Murkland Elementary School**
**350 Adams Street**
**Lowell, Massachusetts**

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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## Background/Introduction

At the request of the Lowell Health Department and Principal Roger Landry, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality issues and health concerns at the Murkland Elementary School in Lowell, Massachusetts.

On January 23, 2002 Cory Holmes, Environmental Analyst of the Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an indoor air quality assessment. Dick Clancy, Senior Custodian, accompanied Mr. Holmes during the assessment.

The school is a two-story brick building built in the early 1990s. The second floor consists mainly of general classrooms and a library. The first floor contains general classrooms, art room, offices, gymnasium and cafeteria.

## Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Moisture content in the interior lining of the rooftop air handling unit (AHU) was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

## Results

This elementary school houses pre-kindergarten through grade 4, with a student population of approximately 500 and a staff of approximately 90. Tests were taken under normal operating conditions and results appear in Tables 1-5.

## Discussion

### Ventilation

It can be seen from the tables that the carbon dioxide levels were elevated above 800 ppm (parts per million) in twenty-one of forty-four areas surveyed, indicating ventilation problems in these areas of the school.

Fresh air in classrooms is supplied by wall or ceiling-mounted unit ventilators (univents) (see Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (see Picture 1) and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and a heating coil, and is then expelled from the univent by motorized fans through fresh air diffusers. Univents were operating in all areas surveyed. Obstructions to airflow, such as books, papers and posters on top of univents, as well as desks and carts in front of univent return vents, were seen in a number of classrooms (see Picture 2). To function as designed, univents and univent returns must remain free of obstructions.

Ventilation in the gymnasium, cafeteria, interior rooms and offices is provided by air handling units either located in mechanical rooms or on the roof. Complaints of stuffiness and lack of circulation thought to contribute to symptoms (e.g., itchy eyes, respiratory irritation) were reported in the main office suite, which includes the nurse's office. No airflow was detected in any of the rooms in this area. It was determined that the panel switch controlling the HVAC system in this area had been deactivated (see Picture 3). Without the HVAC system operating as designed, normally occurring pollutants cannot be diluted or removed allowing them to build up and lead to indoor air quality/comfort complaints.

The mechanical exhaust ventilation system consists of ceiling-mounted exhaust vents (see Picture 4). Exhaust vents were not functioning in a number of classrooms, which can indicate that the exhaust ventilation was deactivated, or that rooftop motors were not functioning. BEHA staff examined exhaust motors on the roof and found exhaust motors REF-2 & REF-5 were not operating. In addition, exhaust ventilation for the classroom 101 restroom was not operating at the time of the assessment.

The location of some exhaust vents can limit exhaust efficiency when the classroom hallway doors are open (see Picture 5). When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms. Without removal by the exhaust ventilation, normally occurring pollutants can build up and lead to indoor air complaints.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (BOCA, 1993; SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is

impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches (see Appendix I).

Temperature readings were within a range of 68$^{o}$ F to 76$^{o}$ F, which were close to the BEHA recommended range. The BEHA recommends that indoor air temperatures be maintained in a range of 70$^{o}$ F to 78$^{o}$ F in order to provide for the comfort of building occupants. A number of temperature control complaints were expressed to BEHA staff during the assessment, which may indicate that thermostats are malfunctioning and may need repair/replacement. Specific heat complaints were expressed in computer room 218. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in this building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 16 to 35 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

**Microbial/Moisture Concerns**

A perimeter inspection of the building was conducted in which BEHA staff noted a potential problem due to the lack of a complete drainage system. Pictures 6-8 depict a green organic material (possibly moss or algae) growing on exterior brickwork near the main entrance of the building. The pattern and location of growth is consistent in areas equipped with metal roofs that are not equipped with gutters or downspouts. The lack of proper drainage allows back-splashing rainwater to impact on the ground below and chronically wet the exterior walls.

Gutters and downspouts are designed to collect and direct rainwater away from the base of the building to prevent the chronic wetting of exterior walls which can result in damaged brickwork and/or mold growth. Over time rainwater can work its way into mortar and brickwork causing cracks and fissures, which can lead to water penetration as well as the increased degradation of structural integrity.

Several classrooms had a number of plants. Moistened plant soil and drip pans can be a source of mold growth. The lack of drip pans can lead to water pooling and mold growth on windowsills. Plants are also a source of pollen. Plants in several classrooms were noted near univent air diffusers (see Picture 9). Plants should be located

away from the air stream of ventilation sources to prevent the aerosolization of mold, pollen or particulate matter throughout the classroom.

A few water-damaged ceiling tiles were noted reportedly from historic roof leaks and/or from the HVAC system (see Picture 10). If wetted repeatedly, porous materials can grow mold and be a source of unpleasant odors. Water-damaged building materials should be replaced after a water leak is discovered.

In a number of classrooms, paper products, board games and other porous items were found stored underneath sinks. If these items become wet repeatedly they can provide a medium for mold growth. These items should be relocated to a warm, dry environment.

**Other Concerns**

Several other conditions were noted during the assessment, which can affect indoor air quality. Cleaning products and other unlabeled materials were found on counter-tops and beneath sinks in a number of classrooms (see Picture 11). A number of classrooms contained unlabeled spray bottles. Products should be kept in their original containers or clearly labeled as to their contents for identification purposes in the event of an emergency. The scent of deodorizer was detected upon entry into the music room and several restrooms. The source of the odors were identified as air fresheners plugged into electrical sockets in restrooms and a conventional time-released air freshener in the music room. Air fresheners and cleaning products contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. In addition, air fresheners do not remove materials causing odors, but rather mask odors which may be present in the area.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed to be piled on windowsills, tabletops,

counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate. These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. These items should be relocated and/or cleaned periodically to avoid excessive dust build up. A number of exhaust vents in classrooms, restrooms and in the gymnasium had accumulated dust on their grills. If exhaust vents are not functioning, backdrafting can occur. Backdrafting can re-aerosolize dust particles. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving, and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Several areas contained lamination machines and/or photocopiers. Lamination machines give off odors. Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). School personnel should ensure that local exhaust ventilation is activated while equipment is in use to help reduce excess heat and odors in these areas.

During the perimeter examination of the building, several hornet/wasps' nests were observed along the exterior wall/roof eave outside of rooms 104 & 105. These nests should be removed in a manner as to not introduce pesticides and/or insects into the building to prevent potential problems.

A pungent odor was detected upon entry into pre-kindergarten room 101. This odor was traced to a number of vinyl mats that children use during naptime (see Picture

12). Although no health effects or symptoms were reported, these types of nuisance odors can be problematic for certain sensitive individuals.

BEHA staff examined filters in AHUs in mechanical rooms and on the roof and found filters coated with dirt/dust and accumulated material (see Pictures 13 & 14). A debris-saturated filter can obstruct airflow and may serve as a reservoir of particulates that can be re-aerosolized and distributed to occupied areas via the ventilation system. School officials reported that the Lowell Department of Public Works (LDPW) is responsible for maintaining HVAC equipment, including filter changes. School officials report that recently school maintenance personnel are allowed to change filters in wall-mounted classroom univents (but not AHUs or ceiling-mounted univents). Although this reallocation of responsibility will benefit certain classrooms, it may create conditions of inconsistent preventative maintenance.

Ant infestation was reported in pre-kindergarten classroom 101. Insect fragments can become dried out and aerosolized and may serve as a source of allergenic material for sensitive individuals. The most likely route for insect penetration into the building is through spaces along exterior walls/baseboards. Under current Massachusetts law effective November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). A copy of the IPM guide is attached as Appendix II. The reduction/elimination of pathways of egress into the building should be the first step taken to eliminate this infestation.

Complaints of vehicle exhaust odors have been reported within the building. Picture 15 depicts the potential for vehicle exhaust to be pulled into the univent fresh air intakes (called entrainment). Idling vehicles can result in the entrainment of vehicle exhaust into the building, which may, in turn, provide opportunities for exposure to compounds such as carbon monoxide. M.G.L. chapter 90 section 16A prohibits the

unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1996).

## Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made:

1. Continue to work with the LDPW to develop a preventative maintenance program for all HVAC equipment.
2. Change filters for AHU equipment as per the manufacturer's instructions or more frequently if needed. It is important that filters for *all* HVAC equipment (i.e. univents and AHUs) are changed on the same schedule to maintain consistency.
3. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.
4. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a

heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.

5. Remove all blockages from univents and exhaust ventilators to ensure adequate airflow. Clean out interiors of univents.

6. Once both the fresh air supply and the exhaust ventilation are functioning properly, the system should be balanced by an HVAC engineering firm.

7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8. Calibrate, repair and/or replace thermostats as necessary to maintain control of comfort.

9. Keep plants away from univents in classrooms. Ensure plants have drip pans, avoid over-watering, and examine drip pans for mold growth and disinfect areas with an appropriate antimicrobial where necessary.

10. Replace any remaining water-stained ceiling tiles, wall board and pipe insulation. Examine the areas above and around these areas for mold growth. Repair water leaks and disinfect areas of water leakage with an appropriate antimicrobial if necessary.

11. Inspect/install drainage to prevent the impact of back-splashing rainwater on exterior brickwork. Remove growth and disinfect areas on exterior brickwork with an appropriate antimicrobial as needed.

12. Do not store paper products or other cellulose-containing materials beneath sinks.

13. Store cleaning products and chemicals properly and keep out of reach of students.

14. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

15. Ensure exhaust ventilation is functioning in areas that contain lamination machines and photocopiers.

16. Refrain from using strong scented materials (e.g., air fresheners) in classrooms and restrooms.

17. Periodically clean exhaust vents of accumulated dust and debris.

18. Consider removing or replacing vinyl mats in pre-kindergarten classroom 101.

19. Relocate student drop off area or consider posting signs instructing drivers to shut off engines after five minutes as required by Massachusetts General Laws 90:16A.

20. Use IPM to remove pests from the building (see Appendix II) (MDFA, 1996). Activities that can be used to eliminate pest infestation may include the following activities:

    i) Consult a licensed pesticide applicator on the most appropriate method to end infestation.

    ii) Reduce/eliminate pathways/food sources that are attracting pests.

    iii) Reduce harborages (plants/cardboard boxes) where pests may reside.

## References


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MGL. 1996. Stopped motor vehicles; Operation of Engine; Time Limit; Penalty. Massachusetts General Laws. M.G.L. c. 90:16A.

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Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

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**Picture 1**

**Univent Fresh Air Intake**

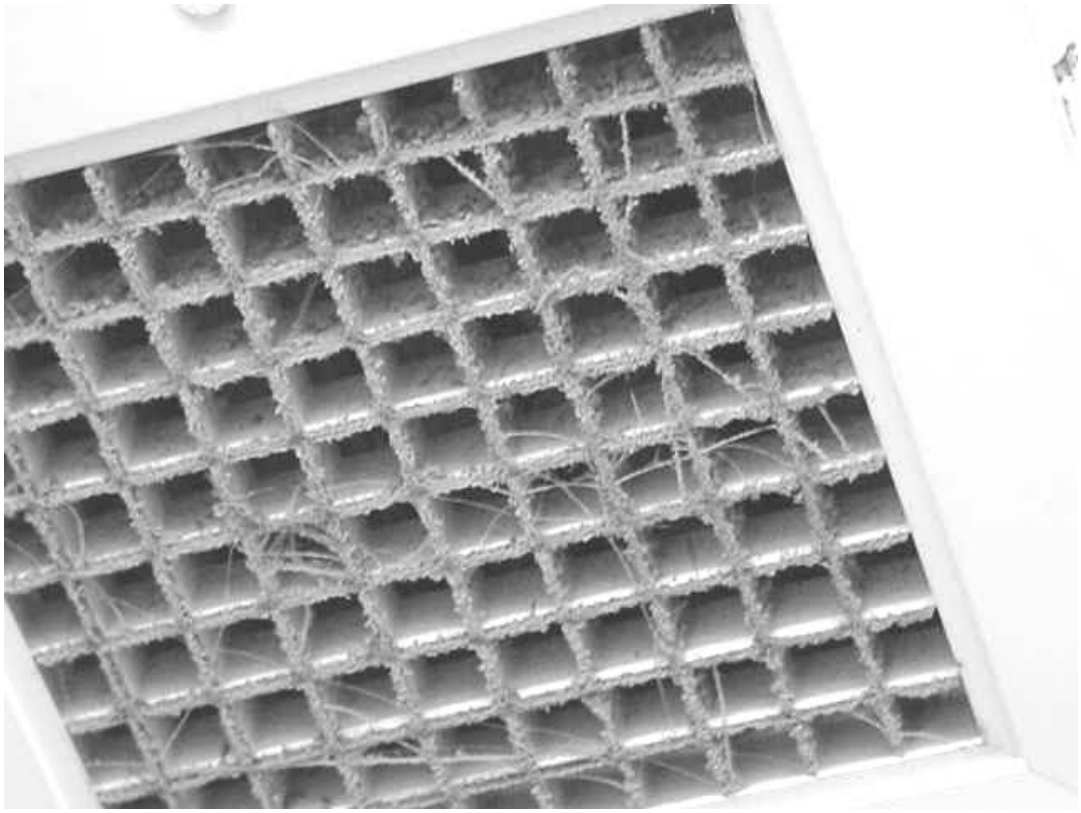
**Picture 2**


**Items on Top of and in Front of Univent**

**Picture 3**

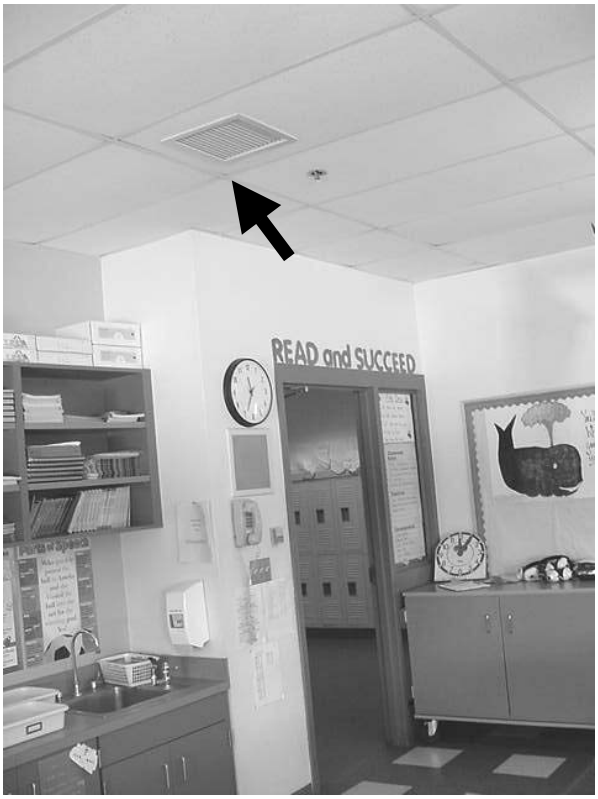

**Control Switch Deactivating AHU in Main Office Suite**

**Picture 4**



**Ceiling-Mounted Exhaust/Return Vent,**
**Note Dust/Cobweb Accumulation**

**Picture 5**




**Proximity of Ceiling-Mounted Exhaust Vent to Hallway Door**

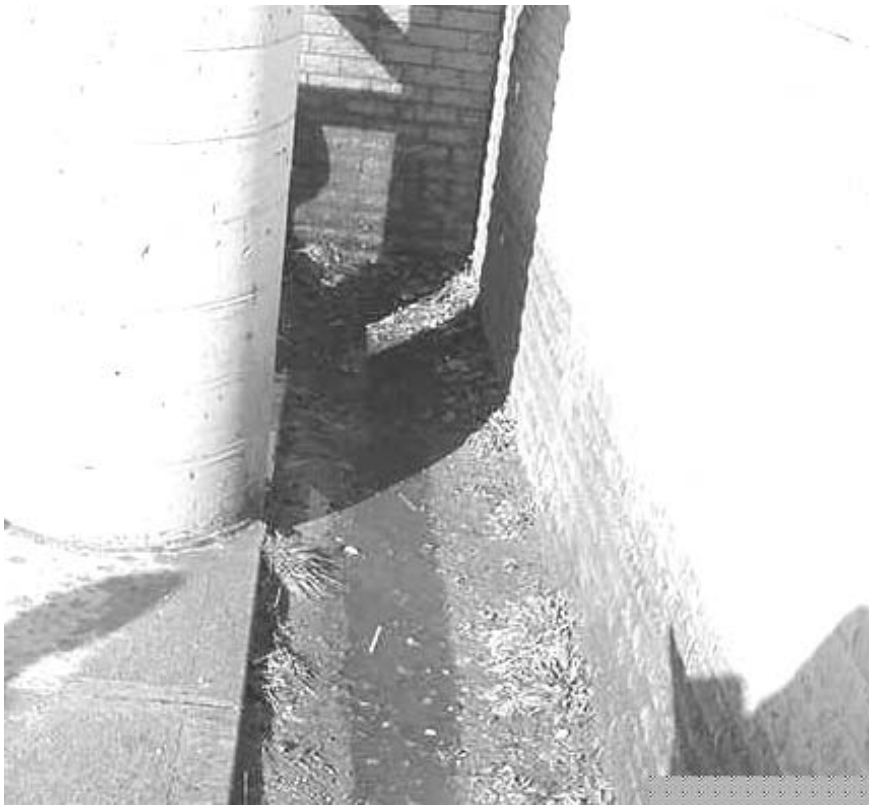
**Picture 6**

**Metal Roof not Equipped with Gutters/Downspouts;**
**Note Staining/Water Damage of Brickwork Due to Backsplashing**

**Picture 7**

**Close-up of Water Stained/Damaged Brickwork**

**Picture 8**



**Brickwork (Near Front Entrance) Impacted by Lack of Drainage;
Note Standing Water in Trench Parallel to Exterior Wall**

**Picture 9**

**Flowering Plants on Top of Univent**

**Picture 10**

**Water-Damaged Ceiling Tiles**

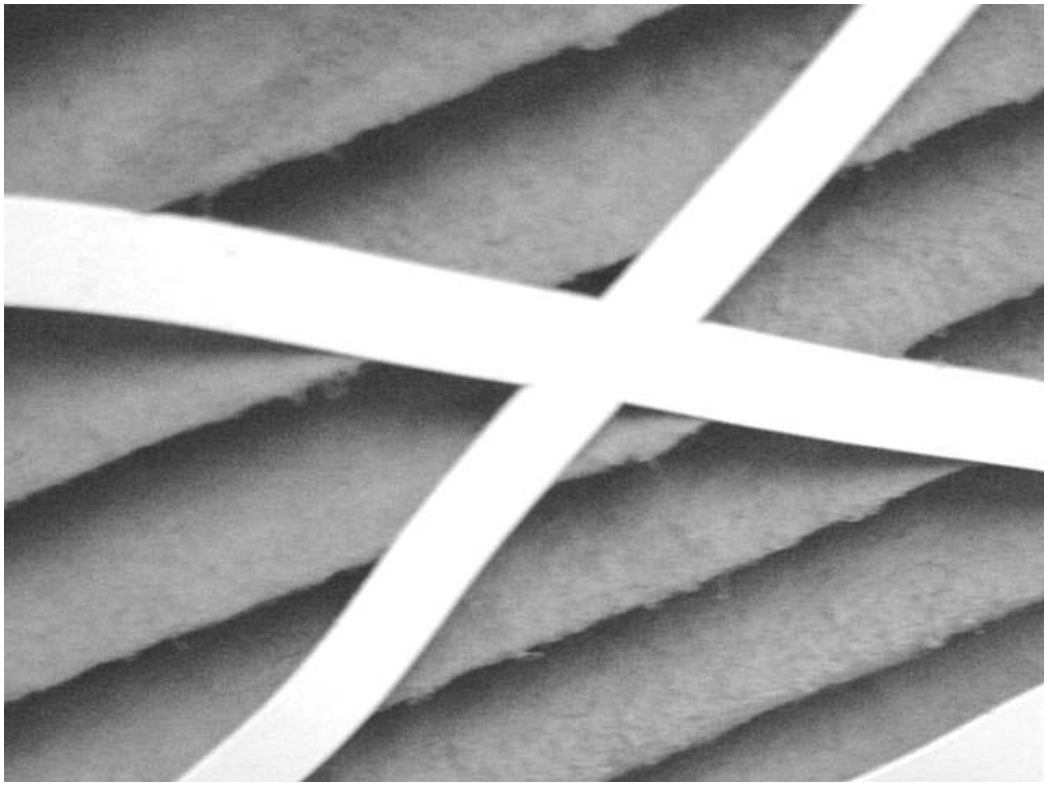
**Picture 11**


**Cleaning and Unlabeled Products beneath Classroom Sink**

**Picture 12**

**Vinyl Mats Emitting Odors Found in Pre-Kindergarten Classroom 101**

**Picture 13**



**Mechanical Room AHU Filter Covered With Dust/Debris**

**Picture 14**

**Rooftop AHU Filter Covered With Dust/Debris**

**Picture 15**


**Mini-bus Idling Outside of Fresh Air Intake During School Hours**